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Immune Response to Bacteria: An Integrated Learning Module to Enhance Preclinical Students' Competency in Immunology

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Abstract

Introduction: Medical students express frustration that they cannot assemble a comprehensive big picture of how the immune system responds to a microbe and that integration of basic science knowledge, especially across disciplines, with clinical knowledge is difficult. Yet medical student competency requires application of knowledge of immune mechanisms to inform diagnosis and treatment. **Methods:** A diagram for immune response to extracellular microbes was previously published by MedEdPORTAL in 2011. This diagram has been updated here as a narrated audiovisual module with integrated histopathology. It contains a self-assessment quiz that tests students' understanding of the module followed by a clinical vignette that tests students' ability to apply the concepts in a clinical context. The module was published and usage was tracked via our learning management system. An in-class survey was conducted to gauge students' perceptions of the module. **Results:** Eighty-two out of 102 (76%) first-year medical students used the module. Over 85% of survey participants felt that the module was a useful resource for learning and reviewing. More than 90% felt that the module helped them to understand the big picture and identify areas for further study. **Discussion:** This module assembles a big picture of the immunologic mechanisms involved in a bacterial infection. It was created in response to requests and suggestions by preclinical medical students and used for first-year students during the first few weeks of their training in the basic sciences. This approach integrates multiple disciplines and facilitates students' learning and application of difficult concepts in immunology and pathology.

Keywords

Bacteria, Complement, Antibody, Lymphocytes, Antigen, Immune Response, Neutrophils, Macrophages, Opsonization, Pathology, Immunology

Educational Objectives

By the end of the module, the learner will be able to:

1. Understand an integrated and comprehensive big picture of the immune response to a bacterial infection.
2. Self-assess and apply knowledge of immune mechanisms utilized to defend against a bacterial infection.

Introduction

The 2009 Scientific Foundations for Future Physicians Report of the AAMC-HHMI Committee¹ recommends overarching principles and competencies that all medical students should demonstrate. One such overarching principle states that "modern medicine requires the ability to synthesize information and collaborate across disciplines."¹ M4, an associated learning objective for competency most related to immunology, states that students should be able to "apply knowledge of the mechanisms utilized to defend against intracellular or extracellular microbes to the development of immunological prevention or treatment."¹

Appendices

- A. Immune Response to Bacteria Module.swf
- B. Quiz.swf
- C. Case With Questions.swf
- D. Printable Quiz With Answers.doc
- E. Printable Quiz Without Answers.doc
- F. PowerPoint Presentation .pptx
- G. Survey.pdf

All appendices are peer reviewed as integral parts of the Original Publication.

A learning resource entitled “Immune Response to an Extracellular Microbe”² was created after students’ responses on surveys at our medical school indicated that although they felt they were learning about immune responses, they did not feel they could assemble what they were learning into a comprehensive big picture for its application. The learning resource was initially published by MedEdPORTAL in 2011² and has been downloaded 43 times by 36 unique users, including faculty and students in medical, dental, and pharmacy schools across the US and Canada. We created a new resource that updates the original and includes current immunology and instructional design concepts. It is now integrated across disciplines, including immunology, pathology, and histology, and provides multiple opportunities for retrieval practice and self-assessment.

This resource is intended to help medical students assemble a comprehensive big picture of the immune response to bacterial infection and integrate the relevant pathologic and clinical data. It utilizes a theory of learning emphasizing that students’ learning and recall of new material improve when the material is provided in an integrated and clinical context, rather than in a series of individual silos of information.

Integration of basic science and clinical medicine in an undergraduate medical curriculum is challenging and has been the subject of debate. Recent major educational reports highlight the need for integration in medical education.^{3,4} Curriculum integration can be achieved at various levels, that is, program, course, or session level. This resource provides session-level integration using the concept of contextualization of basic science concept teaching and shared teaching. Contextualization is the demonstration of basic science principles in a clinical case or situation to provide a more practical, applied setting for knowledge.³ In an audiovisual module, the immunology and pathology of the immune response to bacterial infection are followed by a clinical vignette and self-assessment quiz requiring practical application of basic science knowledge in a relevant clinical setting. This resource is a collaborative effort between basic science and clinician medical educators and therefore represents the shared teaching method, in which basic scientists and clinicians come together to teach a course.³

This resource was originally designed for use at Texas Tech Health Sciences Center Paul L. Foster School of Medicine (PLFSOM) in El Paso, Texas.² PLFSOM utilizes an integrated 2-year preclinical curriculum that is systems based and organized into 100 common chief complaints or clinical presentations. Students are introduced to each clinical presentation in the form of a branching diagram called a scheme that illustrates how experts organize the information associated with that clinical presentation. Each scheme illustrates the major decision branch points in the diagnostic reasoning of an expert clinician in the field. The clinical schemes are presented at the beginning of each week of instruction by a clinician in that specialty. The rest of the week is devoted to learning the basic science that is the basis for the diagnosis of the symptoms within the clinical presentation. Immunology is introduced in an early curriculum unit entitled Introduction to Health and Disease. The content for this resource occurs during Weeks 1-3 of the curriculum. The resource itself is made available to the students during the third week when the clinical presentation is on sore throat and students are beginning to apply basic concepts of innate and adaptive immunity to the process of a bacterial infection.

This updated resource includes an audiovisual module with relevant histopathologic material, a clinical vignette, and self-assessment quiz items to provide an opportunity for the application and integration of basic science knowledge across disciplines, toward an overarching principle of medical student competency. A prerequisite for utilization of the resource is an introductory knowledge of innate and adaptive immune responses to specific stimuli. Detailed knowledge of immune system function is not necessary. The ideal context for implementation would be during an introductory course in microbiology and immunology where responses to bacterial pathogens are taught.

Methods

The original diagram/learning resource, “Immune Response to an Extracellular Microbe,” was published by MedEdPORTAL in 2011.² It has been updated here to reflect current concepts in immunology and to

illustrate the idea that the immune system is not static and that immune cells move to different locations in the body when needed. The educational approach utilized is one designed to foster independent lifelong learning. A big-picture integrated audiovisual module (Appendix A) based on two textbooks written for medical students^{5,6} presents a step-by-step explanation of immune mechanisms involved in a bacterial infection. The module's purpose is to aid medical students in the organization of their knowledge of the immune system by describing how the various mechanisms in an immune response come together to collectively defend against an extracellular microbe. Relevant pathology and histology images are incorporated. Students are also provided with a self-assessment quiz that tests the concepts learned in the module and a clinical vignette, accompanied by multiple-choice questions, highlighting the clinical application of the basic science concepts.

The audiovisual module (Appendix A) is in small web format (.swf). Created using iSpring Suite 8.5 software, the module is a Shockwave Flash object and can be run on any browser that has Adobe Flash Player 10 and above. Most browsers have an integrated Flash movie player, and the file can be played by dragging and dropping it into the browser's address window. The module was published on our learning management system (LMS) as Shareable Content Object Reference Model (SCORM) 1.2-compliant content (zipped folder), which allowed us to track module usage and quiz scores.

The user can download this module from MedEdPORTAL and play it either by using an Adobe Flash player or by right-clicking on the file and opening it with a web-based browser. To open the module using a browser, select the Open With button, choose a browser (e.g., Google Chrome or Internet Explorer), and play the module. At the end of the narration, students may take a self-assessment quiz composed of 18 questions, which is followed by a clinical vignette with an attached quiz. For students who want to repeat the quizzes, they are also provided separately in Appendices B (quiz only) and C (quiz with case). Together, these appendices constitute an online learning resource that can be published on any LMS.

Once a given slide's narration ends, the Flash movies automatically advance to the next slide. Students can also move to the next slide by clicking the Next button or the slide number provided in the outline. Alternatively, students can skip the narration and go straight to the quiz or clinical vignette. A detailed explanation is provided in the notes section of each slide.

The materials provided in Appendices D, E, and F are intended for in-class teaching. Appendices D and E, contain the same self-assessment questions but in Word format with and without answers, respectively. Appendix F contains the same material as Appendix A in a PowerPoint format.

The resource was published as part of the recommended learning materials for immunology sessions during the sore throat clinical presentation in the third week of the curriculum. Usage was tracked via our LMS (Canvas). An anonymous seven-question survey was administered during class using an audience response system (Poll Everywhere) to gauge students' use and perceptions of the module as a learning tool (Appendix G).

Results

Out of a class of 108 students, 82 (76%) accessed the module; some accessed it multiple times. Fifty-nine students participated in an anonymous in-class survey, and 52 students reported using the module. Most of the students (86.5%) felt that the module was useful when learning material for the first time (Table, Question 3). The majority of students felt that the module helped them identify areas of weakness (94.1%, Question 4), was helpful in reviewing the material (96.1%, Question 5), and helped them to understand the big picture (96.2%, Question 6). Students also considered the module more comprehensive than those in other immunology resources (96.1%, Question 7).

Table. Survey Results

Question Number	Respondents (N)	Strongly Agree (%)	Agree (%)	Slightly Agree (%)	Slightly Disagree (%)	Disagree (%)	Strongly Disagree (%)
3	51	30.8	44.2	11.5	7.7	5.8	0
4	51	35.3	49	9.8	2	3.9	0
5	53	54.9	31.4	9.8	0	3.9	0
6	52	47.2	35.9	13.2	0	3.8	0
7	52	55.8	23.1	17.3	3.9	0	0

Discussion

This module is designed as a self-learning resource for first-year medical students. We use it in a clinical presentation–based immunology curriculum as part of the first unit (Introduction to Health and Disease); however, it can be used in any basic immunology course when students are introduced to innate and adaptive immunity. Its use during the sore throat clinical presentation week in our curriculum provides a relevant clinical context and integration of disciplines. The module is based on Dr. Piskurich's original diagram, which was designed in response to students' failure to understand the sequence of events in the immune response to bacteria and published by MedEdPORTAL in 2011.² Survey results are very encouraging and indicate that students consider this module a valuable learning tool that enhances their learning experience. One limitation of this resource is that it is not intended as a stand-alone course in immunology. It is designed to help contextualize and review material for an existing immunology curriculum and, as such, can be used as a component of self-directed learning; it might also be used as a portion of a remediation plan.

Using the principles of shared teaching and session-level integration,³ faculty from clinical pathology and immunology collaborated to enhance this learning resource by providing clinical context and highlighting the localization and mobility of immune cells during the immune response. A quiz and clinical vignette with questions were added because Baatar, Lacy, Mulla, and Piskurich recently showed that repeated use of self-assessment quizzes as learning tools (self-testing) improves medical student performance on basic science examinations.⁷ This redesigned module with an added clinical vignette provides contextualization and represents a significant improvement over the original version.

A challenge to implementation of the module might be a nonpathologist's reluctance to use histologic images because of lack of familiarity with them. We have labeled these images and provided explanations to make their interpretation/presentation easier. Some students might have problems with these histologic images for similar reasons; therefore, we have identified the basic cell types and tissues along with the type of staining for each image.

Another limitation of our study is that the response rate for students completing the study survey was not high. We learned that some of the students saved the module for studying for the summative exam a few weeks later and had not yet accessed the module at the time of the in-class survey. Since neither class attendance nor completion of the survey was mandatory, we may not have captured responses for students who are more self-directed and actually prefer to use online learning resources to augment their study. Evaluating the learning module's impact on student learning was also a challenge since designing questions based on material in the module but not also presented elsewhere was impossible. For this reason, we based our study on students' assessment of the module's usefulness for their learning. Students are now requesting additional modules much faster than we are able to provide them, again suggesting that they view them as valuable learning resources.

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Disclosures

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Ethical Approval

This publication contains data obtained from human subjects and received ethical approval.

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